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# Analysis of BLT data from VKI Longshot Facility

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U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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# Run Conditions

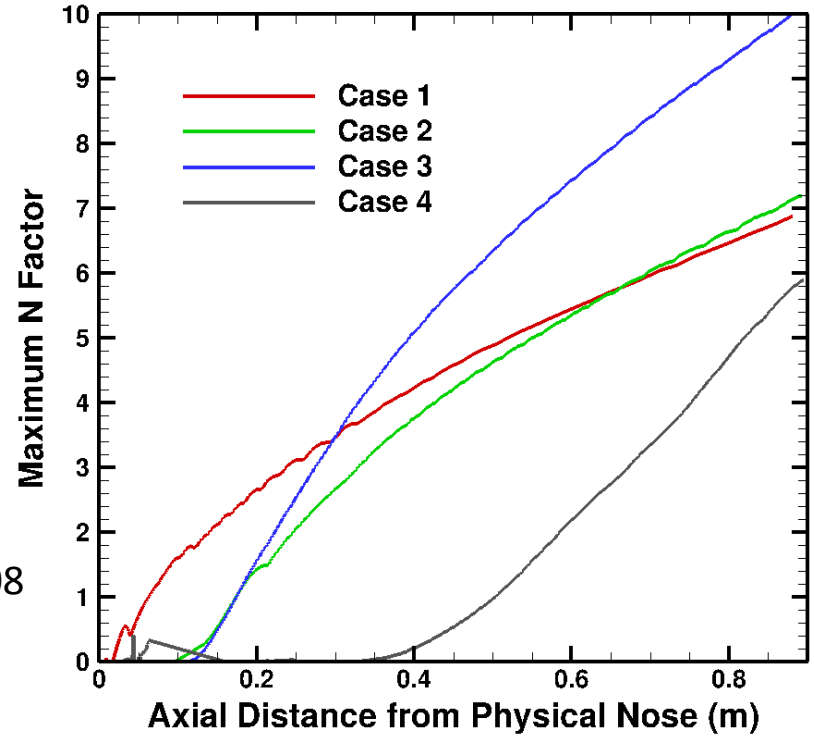
- Simulation parameters
  - Cone Model
    - 7 degree cone; 800mm long
    - Simulated length of 900mm
    - Wall temperature 293 K
  - Freestream gas of ideal $N_2$ –
    - Molecular Weight 28.014, $c_p = 1038.8$ J/kg/K
    - Sutherland's law for viscosity $\mu = \mu_{ref}\frac{T^{3/2}}{(S+T)}$; $\mu_{ref} = 1.458e-6$ kg/s/m; $S = 102.7$ K
    - Eucken's relation for thermal conductivity – Corresponds to Prandtl number of 0.736
  - Conditions:

| Case | P (Pa) | Rho (kg/m$^3$) | T (K) | V (m/s) | Mach | Re (1/m) | Nose (mm) | Streamwise cells | Wall-normal cells |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 262 | 1.23993E-02 | 71.2 | 1727 | 10.04098 | 4.25119E+06 | 0.05 | 1615 | 300 |
| 2 | 277 | 1.34298E-02 | 69.5 | 1689 | 9.939415 | 4.62379E+06 | 1.75 | 820 | 300 |
| 3 | 496 | 2.51703E-02 | 66.4 | 1781 | 10.72268 | 9.60919E+06 | 1.75 | 820 | 300 |
| 4 | 566 | 2.97532E-02 | 64.1 | 1930 | 11.82638 | 1.28010E+07 | 4.75 | 680 | 300 |

# Stability Results

- N factor trends
  - Increasing Reynolds number results in more amplification
  - Increasing nose radius results in less amplification
- Transition N factor: $N_{cr}$
  - Most amplified frequency= f
  - Decreases with increasing Re
    - Contradicts Marineau et al. 2014-3108

| Transition location (s-mm) | Distance from Nose (x-mm) | $N_{cr}$ | f (kHz) |
|---|---|---|---|
| 550 | 545.54011 | 5.133439 | 204.4589 |
| 690 | 672.24720 | 5.813866 | 183.91 |
| 400 | 384.40882 | 4.825988 | 331.97 |
| 710 | 670.48160 | 2.89695 | 260.52 |

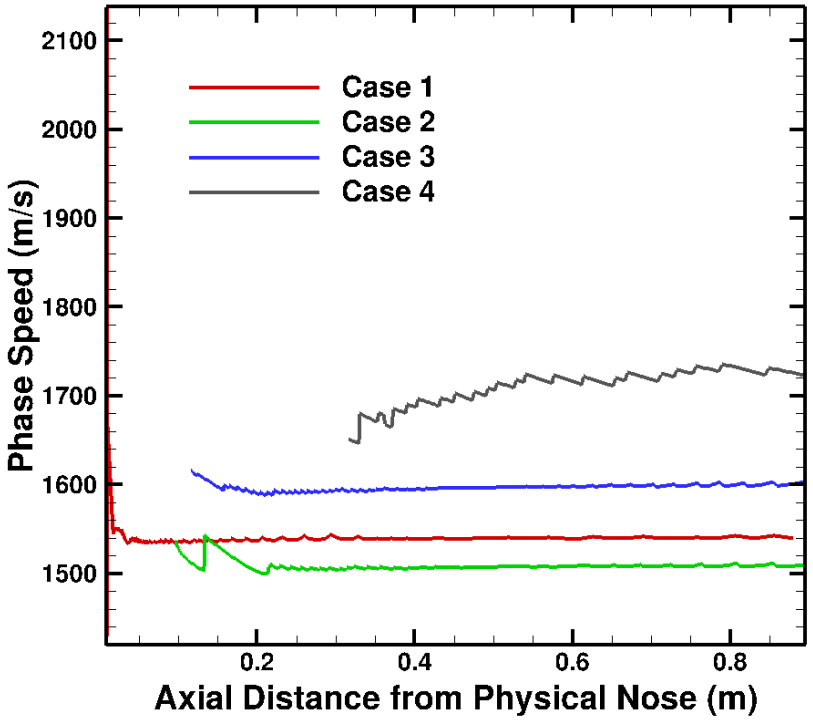



**Maximum N factor for all cases tested**

# Stability Results

- Phase Velocities
  - Calculated values based on most amplified disturbance
  - Measured values approximated from figures 13 and 14
  - Normalized ($U_c/U_e$) values approximated from LST diagram

| Group Velocity from paper (m/s) | Calculated | ~$U_c/U_e$ |
|---|---|---|
| N/A | 1540 | 0.93 |
| 1650 | 1500 | 0.93 |
| 1700 | 1600 | 0.94 |
| 1950 | 1700 | 0.92 |




**Phase velocity for most amplified disturbance for all cases tested**

# Sensor locations

- Sensor locations converted from sharp cone distance to axial distance from the physical nose of the model.
- These are stated for verification:

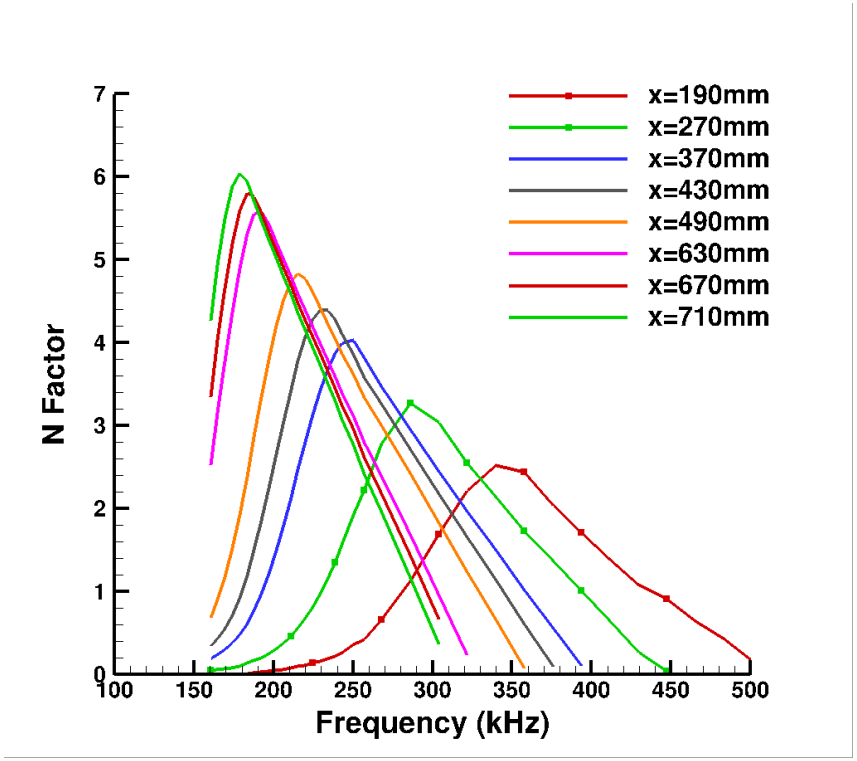
| sensor | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| s (along the surface from a theoretically sharp nosetip, mm) | 190 | 270 | 370 | 430 | 490 | 630 | 670 | 710 |
| x (along the axis, mm) | 188.58 | 267.99 | 367.24 | 426.79 | 486.35 | 625.30 | 665.01 | 704.71 |
| Case 1 | 188.22 | 267.63 | 366.88 | 426.43 | 485.99 | 624.94 | 664.65 | 704.35 |
| Case 2 | 175.97 | 255.38 | 354.63 | 414.19 | 473.74 | 612.69 | 652.40 | 692.10 |
| Case 3 | 175.97 | 255.38 | 354.63 | 414.19 | 473.74 | 612.69 | 652.40 | 692.10 |
| Case 4 | 154.36 | 233.76 | 333.02 | 392.57 | 452.12 | 591.08 | 630.78 | 670.48 |

- Frequency data extracted at each sensor location in the next 2 slides.

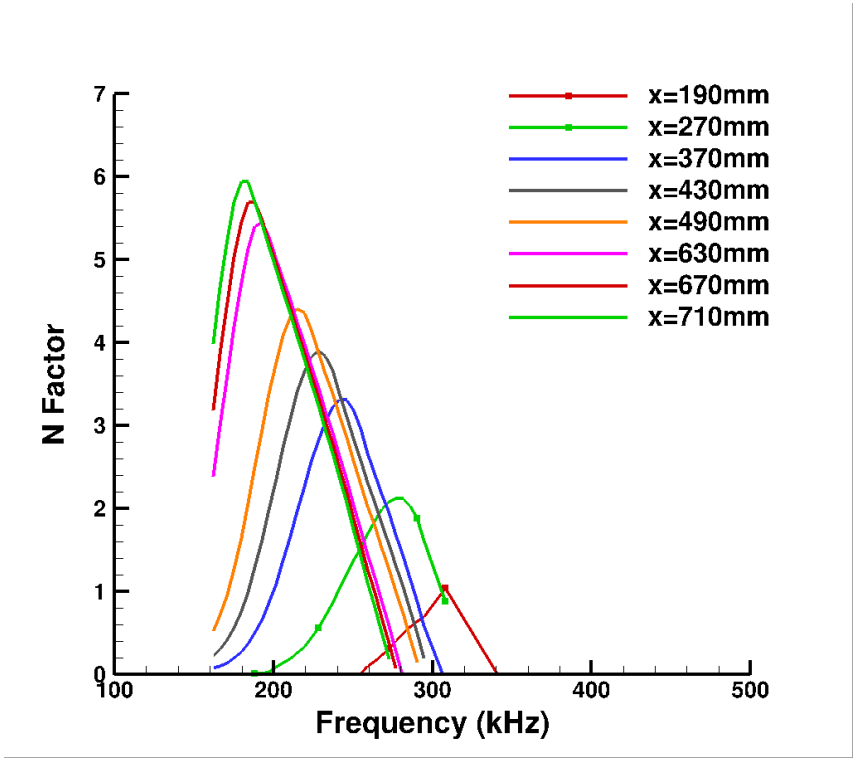
# Frequency Data

- Predicted frequency content at each sensor sampled for the LST data

**Case 1: 0.05mm**



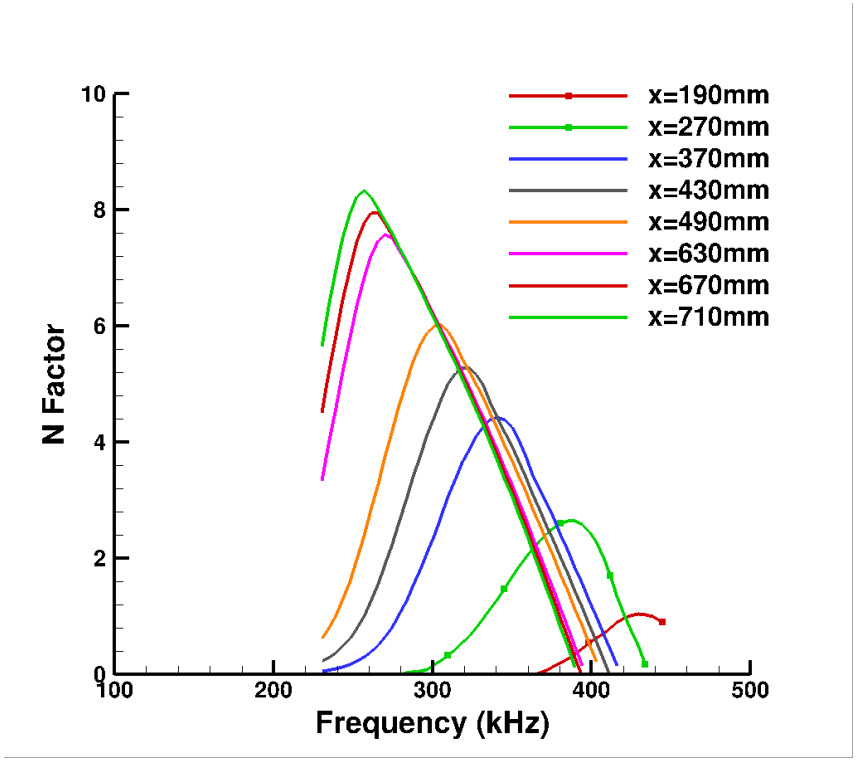

**Case 2: 1.75mm**



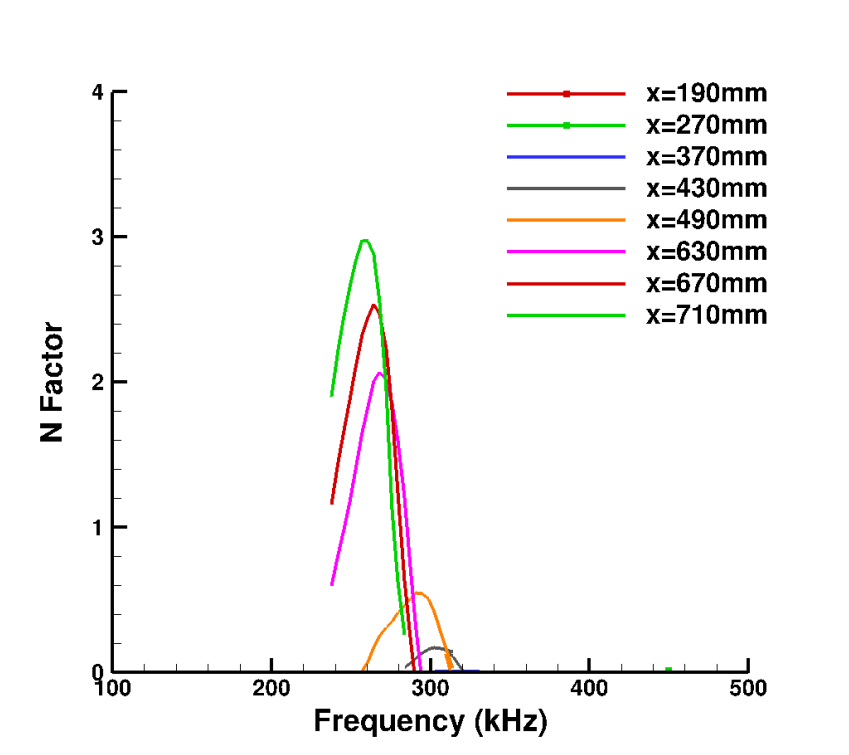
# Frequency Data

- Predicted frequency content at each sensor sampled for the LST data

**Case 3: 1.75mm**

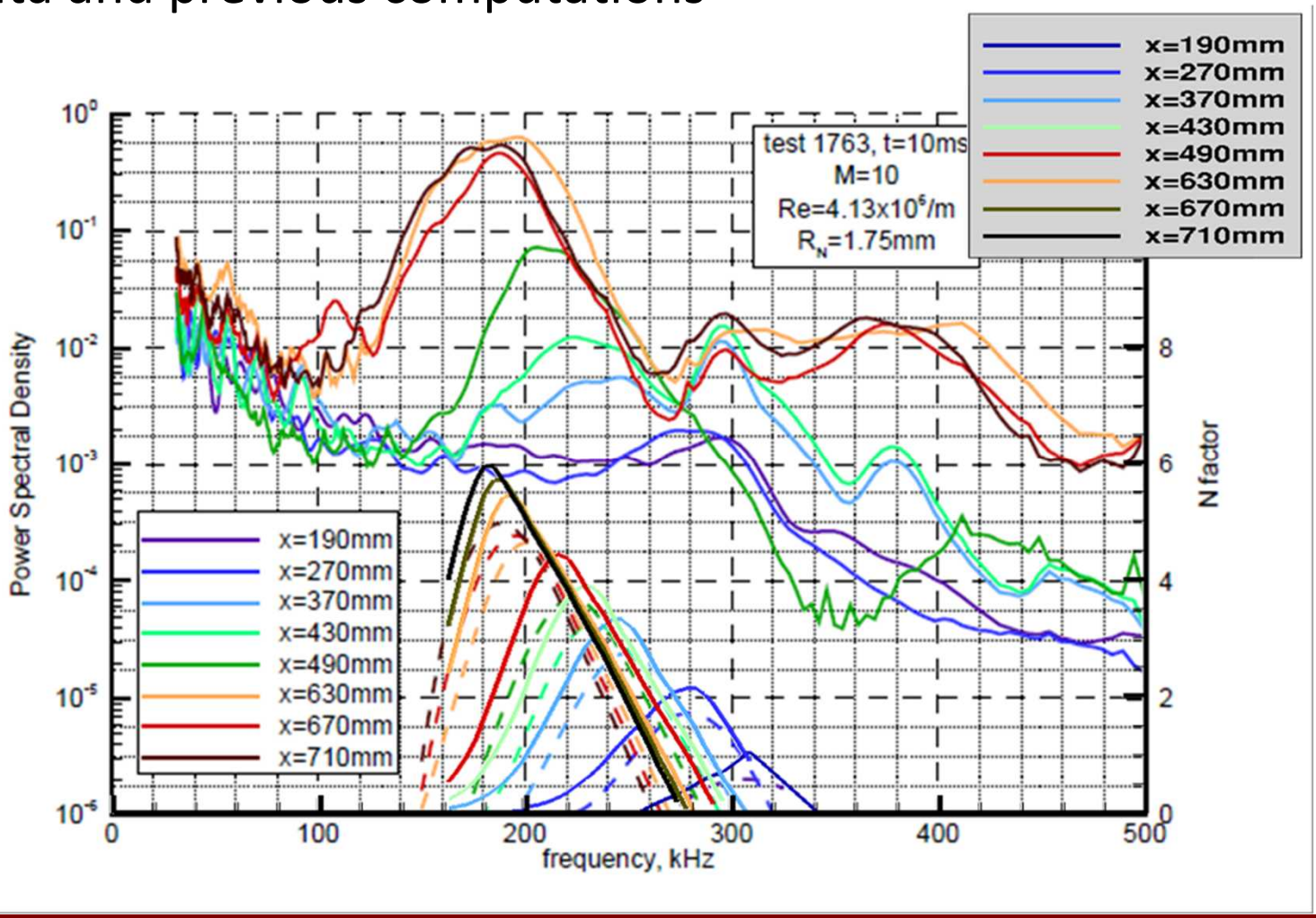



**Case 4: 4.75mm**



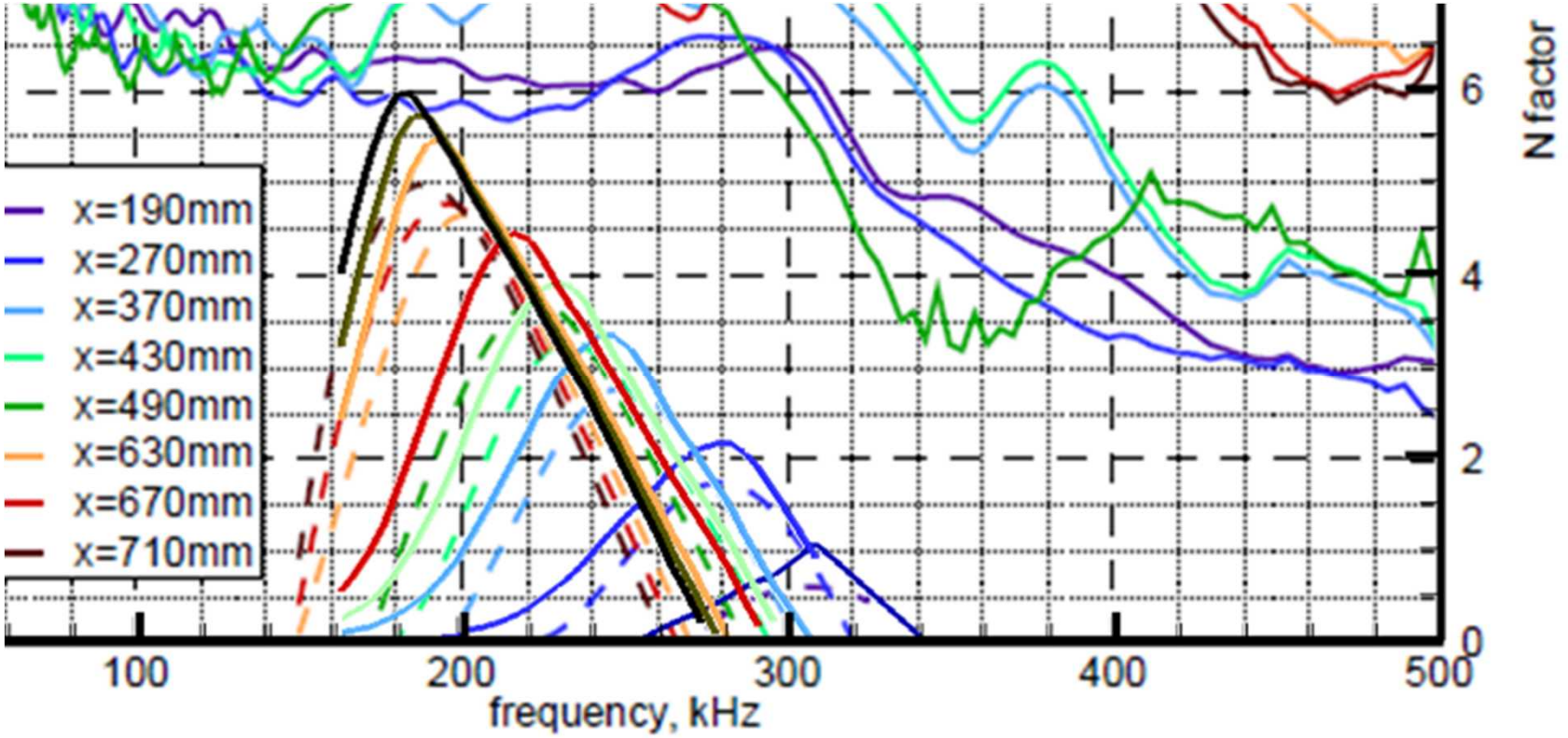
# Case 2: Frequency Data Comparison

- STABL frequency predictions compare well with experimental data and previous computations



# Case 2: Frequency Data Comparison

- A closer view shows STABL predicts similar frequencies as VESTA, but larger N factors



# Summary

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- STABL stability analysis
  - Maximum N factor trends agree well with previous data
  - Transition N factor difference between Case 2 and Case 3 disagrees with previous data. Requires another look
  - Predicts disturbance frequencies that agree with experiments and VESTA computations
  - Predicts larger N factors than VESTA